Co-Development in the Automobile Industry: A Case Study Testing a Win-Win Hypothesis[1]

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Introduction

For the past fifteen years or so, we have been witnessing the emergence of two contradictory trends towards change in the industrial world. On the one side, there is a trend towards vertical restructuring that forces corporations to re-focus on their core skills (Porter, 1982). On the other hand, there is a new approach to design processes, emphasizing close cooperation and teamwork between the various specialists involved in new product design. Changes in the automotive industry perfectly illustrate these opposing trends (Womack & al., 1990; Clark & Fujimoto, 1991; Midler, 1993). In an effort to reconcile the two, corporations are developing new practical relationships, often designated by the terms "design partnership" or "co-development".

The importance of this trends generates many ambiguities and rises questions on two axes :

first on the precise practices behind the so-called «partnership» relationships; many researches (Lamming, 1993; Liker & al., 1995; Midler & al., 1997) try to define more precisely these notions and then characterise the depth and the scope of the changes in the industrial practices.

second on the result of such changes for the car makers *and* the suppliers involved. The general discourse about partnership is that such practices are founded on a «win-win game» hypothesis. There is far less empirical analysis to confirm – nor infirm- this hypothesis, especially on the supplier's side.

In this chapter, we will attempt to provide answers to these questions, basing our conclusions on a case-study of co-development in the die tool development for the automotive industry. The research was a comparizon between two similar projects that adopt different types of supplier-constructor relations (one «traditionnal», one «co-development»).

This chapter is divided into four sections. In the first, we define the concept of "co-development," a term we prefer to "partnership". We analyse on the case how these principles where implemented and what was the consequences in the differences in the development process between traditionnal and co-development project. In the second, we explain the methods used in comparing co-development with the traditional method. In the third section, we present the results of this analysis. As will become apparent, these results substantiate the hypothesis of a "win-win" situation between customer and supplier, although not all suppliers reaped the same benefits. In the fourth and final section, we discuss our results through an analysis of the advantages accruing from co-development in terms of two variables: supplier engineering skills; and long-term stability of the auto-maker/supplier relationship. This analysis reveals the need for systematic integration into the theoretical design-performance model of incentive and cognitive factors.

This article is based on interactive research conducted on the premises of the auto-maker over a period of five years (Garel, 1994). The study is part of a joint research program conducted by the CRG since early 1990 for the purpose of analysing current shifts in design and engineering processes in a variety of industrial contexts: automotive, chemicals, construction, pharmaceuticals, electronics and defence. The research was conducted on the premises of a European mass-market auto-maker, and of a representative sample of the company's stamping-tool suppliers. It was made at the joint request of the auto-maker's purchasing and methods departments. Following the out-location of stamping operations in the early 1990s,

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this auto-maker, which we will refer to as "X," wished to evaluate its new partnerships with suppliers. In the context of a study conducted over a period of two years, we were able to cross-analyse the viewpoints of both the customer and its suppliers. In order to assess the profits and losses generated by co-development, we did a comparative study of two automotive projects: a *TR (Traditional) project*, conducted without co-development in the late 1980s, and a more recent *CD (Co-Development) project*, pioneered jointly with the tool-makers. We chose to analyse the performance of four European tool-makers (A, B, C, D) participating in both the TR and CD projects. The field study was conducted in two phases. From December 1995 to July 1996 we worked from data collected at the auto-maker's. The suppliers' study was conducted from January to July 1997. We drew on internal data collected from Auto-Maker X and its suppliers (files, reports, notes, etc.); on re-assessments made at our request (submitted by the firms); on interviews (over thirty); and on regular cross-checking carried out by the steering committee of the interactive research (Girin, 1990, p. 197).

1. A co-development characterisation

To the rather loose and conoted «partnership» notion, we will prefer the more restrictive term "co-development" thus highlighting the fact that, within the customer-supplier relationship, we are focussing on new product and/or process design. More precisely, following the lines laid down by a previous study (Midler & al., 1997), we have chosen to define "co-development" in terms of five conditioning factors. The idea being that codevelopment efficiency is the result of a global coherency of this set of variables, including definition of tasks, collective design methodologies and contracting rules. This characterisation is consistant with those Lamming (1993) and Liker & al., (1995).

The early selection of a supplier, based on strategic criteria, for a cooperative endeavor lasting throughout the duration of the development process

For co-development, the customer-supplier relationship is formed at the beginning of the design process—during the preliminary study phase. For traditional customer-supplier sub-contracting, on the other hand, this relationship is established only after the technical definition of the new product has been completed, at which point the supplier submitting the lowest bid is selected. For co-development, selection is made on the basis of positive previous experience with the supplier, and on the customer's long-term strategic objectives. Cost bidding—the decisive factor under the traditional system—is here deemed to be less important than compatibility between the customer's strategy and the perceived skills of the supplier. The customer's trust in the supplier and the supplier's reputation also play a role. Approved suppliers are consulted on overall functional objectives (desired level of performance, price objective, etc.). Here, exact technical specifications no longer serve as the point of departure for the customer-supplier collaboration but, on the contrary, are generated by it. The contract is signed only after a period of inter-corporate exchanges during which the supplier evaluates the technical feasibility of the proposed development and estimates the profit potential for its own firm. The customer initiates exchanges with several firms (the "parallel sourcing" concept: Richardson, 1993).
The die tools development includes two phases : phase 1 is design period and ends to a technical specification freeze of the tool. Phase two is a production period of the tools. The difference in suppliers's involvment in TR and CD projects illustrate clearly our first co-development criteria.

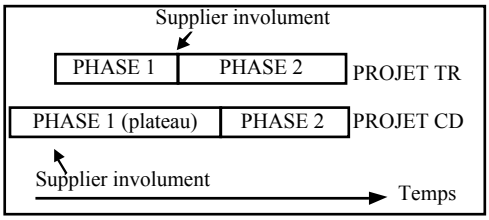


Figure 1: Co-development and the extended supplier time- frame

Phase 1 lasted 4 months on Project TR compared with 18 months on Project CD. Phase 2, on the contrary, was shorter in Project CD. This new time-frame has been defined as «front loading strategies» by Thomke & Fujimoto, (1998). It has been further extended for more recent projects.

Supplier involvement affecting a broader operational perimeter

Co-development implies a shift from basic-component supply to transactions involving complete vehicle sub-systems. For example, in the case of car seats, auto-makers formerly purchased the metal frames, foam filling, and upholstery fabric separately; and then assembled the seat. Under co-development, the supplier provides the complete "system". This broader scope also affects development-cycle operations. Suppliers assume increased responsibility for technical design, process specifications, testing, etc. In the metal-stamping field, assignments to tool-makers are today made by the total lot, and are based on the physical perimeters defining an entire system (for example, all the stamped pieces for a door); whereas, formerly, assignments were made component-by-component and awarded to the lowest bidder. On our CD project, 83% of the components in a lot were assigned to the same supplier, as compared to 43% on the TR project. This way, interface problems between individual components (the geometric fit and visual appeal of the body as a whole) are all handled by the same supplier.

The supplier's commitment to an overall result, measured in terms of quality, cost, and time

In co-development, the supplier's commitment covers the total design / testing / production / delivery process. The customer must be certain that the supplier will use its significant margin of manoeuvre to carry out the co-development project in the direction initially planned. Contractual incentives and sanctions are specified. If difficulties arise, the supplier may risk paying a penalty, losing orders, or failing to be selected as the co-developer on other projects.

Adoption of joined development methodologies focussed on front-loading and learning.

Traditional sub-contracting practice focussed on stipulating the rewards, penalties, and conditions of the relationship as explicitly as possible in the initial contract. However, a design process inevitably involves unforeseen problems, and modifications not included in the original specifications. The skills which need to be mobilized for a design operation are hard to define and coordinate (Schön, 1983; Nonaka, 1994). It is therefore crucial to identify problems quickly, to formulate possible solutions jointly, to implement them, and to optimize the elimination of decision-making inertia when effecting the required modifications. During the course of the project, the proposals made by the various players in the design process must be open to coordination and revision. Suppliers must also be able to demonstrate that the objectives specified in the contract concluded with the customer are tenable. Under co-development, suppliers cannot play a passive role, merely reacting to customer inspections. On the contrary, they have to seize the initiative and ensure that responsibility for the agreed result can be undertaken successfully. It is the supplier's duty to identify potential trouble-spots and to alert the customer if need be. This approach depends on suppliers being able to anticipate and identify problems encountered following the inception of the project. An

agreement between two firms does not have to be exhaustive, but it must be consistent in terms of joint work procedures and the means for dealing with unexpected problems or revised objectives.

The integration of economic and technical imperatives

This integration is twofold. First, under co-development, economic negotiation ceases to be an isolated event and becomes a process of building value through the design process (during which technical variants are costed, the effects of modifications evaluated, etc.), whereas there is a clear separation between economic negotiation and technical design under the traditional customer-supplier relationship. Traditional projects separate the players from each other (the economic contract is formulated by purchasing agents who are largely cut off from the engineering arena of manufacturers), and involve temporal dissociation as well. Under traditional projects, a bid is tendered after major technical decisions have already been made. Secondly, under co-development the integration of economic and technical imperatives arises from the incentives inherent in the method of remunerating the supplier. Because of the close relationship between all the players (payers and producers) involved in the development process, suppliers can be remunerated on the basis of concrete achievement benchmarks, rather than solely on the basis of accounting considerations formulated by the customer's purchasing department.

2. The methodology for evaluating co-development cost performance

Our study is therefore comparative, evaluating the respective results of two projects: one carried out according to the traditional sub-contracting approach (TR project), and the other according to the conditioning factors described above (CD project). First of all, we will describe the three phases of the study conducted at the auto-maker's. We will then present the survey conducted at the suppliers'. Our approach is differential: we have measured the performance differentials between TR and CD projects. Hypothetically, the profit/loss differential observed between the two projects can be attributed to the shift (in one case) to the co-development method. Both projects studied were very similar in terms of vehicle-model, and economic assessments were made in constant French francs (base: year of TR project). Furthermore, the basis of comparison for aggregating data was the same.

The effects of co-development on tool costs

In order to evaluate Phase 1 performance, *we measured, for all tools on Projects TR and CD, the differential between tool cost at the beginning of Phase 1 (or estimated cost) and cost of the same tools at the conclusion of Phase 1*. The first cost corresponds to the initial technical evaluation of the tools. We call this "estimated cost," and it serves as the basis for all of our measurements. Initial specifications for the tools are provided by the systems-engineers of Auto-Maker X: the customer knows how to specify the type of tools it wants to receive from the supplier. The same method of calculation—one widely recognized and employed by suppliers—was used to determine the two costs on both projects. Calculations that do not appear were made for research purposes by the methods department at Auto-Maker X.

The effects of co-development on the negotiated price

Due to large supplier commitment on the global performance of the development, the initial contract fixes globally the remuneration with special clauses dealing with modifications, as explained in the following section. The shift to co-development transforms negotiated pricing into effective remuneration for suppliers; whereas budget overruns were possible under the traditional system. Under the sub-contracting system, each modification became the subject of an amendment to the initial contract. Suppliers were free to negotiate a low initial price, since they knew they would have an opportunity to "hike it up" during the life of the project. *We*

have measured the differentials between estimated tool costs and costs negotiated with suppliers for TR and CD Projects.

The effects of co-development on modifications

Modifications are not unique to the automotive industry, and are actually a feature of the learning process inherent in any industrial design project. The purpose of modifications is to correct a shortfall in product- or process-performance compared with the anticipated result. As the players involved learn about the vehicle (through testing, encountering problems, etc.), the original concept may prove vulnerable. Modifications can vary in importance: from the shift of an opening on a component, to a change in the overall style of the product. Budget overruns caused by modifications can reach 20% to 30% on a given project. For the auto-maker, a major advantage of the shift to co-development is that modifications tend to be reduced in number. Modifications carried out during Phase 2 are the most costly. To embark on Phase 2 is to embark on the stage of project irreversibility, or project reversibility only at an extremely high cost. Tardy discovery of the need for modifications involves heavy additional costs, since at this stage the modifications must be made on the finished tools rather than on the preliminary designs. In other words, modifications can be very valuable during Phase 1, but are extremely costly during Phase 2. *We have measured the value of Phase 2 modifications as a percentage of estimated tool costs for TR and CD projects.*
The advantages and disadvantages generated by modification reduction are not the same for both parties to a co-development contract. Under the traditional sub-contracting system, modifications generate an average of 20% in additional revenues for suppliers. At this rate, modifications can make a crucial difference to suppliers during slack periods. The shift to co-development is therefore a source of apparent loss for tool-makers. For the customers, however, the situation is reversed: under co-development, a reduction in modifications means a reduction in investment. In view of all this, how can the players involved in development projects be persuaded to identify the need for modifications early? How can suppliers be persuaded to forego a major source of revenue?
The co-development project we studied provides a contractual response to these questions. In order to persuade suppliers to play the game of early modification identification, the co-development contract includes (importantly) a clause specifying that no additional costs will be paid for late identification of the need for modifications. A comparison between the traditional and the co-development systems is quite illuminating in this regard.

Table 1: Payment of modification costs for other than co-development projects

	Phase 1 (low cost for unanticipated modification)	Phase 2 (high cost for unanticipated modification)
Originating with Customer	Customer	Customer
Originating with Supplier	Customer (1)	Customer (2)

Under the sub-contracting system, Auto-Maker X is wholly responsible for modifications. Since under this system suppliers do not participate in the design phase of the project, here Phase 1 (1) modifications cannot originate with suppliers. During Phase 2, if the tool-makers suggest modifications, Auto-Maker X must pay the costs, since it bears sole responsibility for the design (2).

Table 2: Payment of modification costs for co-development projects

	Phase 1 (low cost for unanticipated modifications)	Phase 2 (high cost for unanticipated modifications)
Originating with Customer	Supplier (1)	Customer (3)

Originating with Supplier	Supplier (2)	Supplier (4)

(1) During Phase 1, the cost of modifications originating with the customer is defrayed by the tool-maker without any change in the contract. Suppliers are thus encouraged to seek compensation for cost overruns generated by the maker (e.g.: style changes, modifications in the safety system, etc.). This compensation, which reflects an improvement in tool design, leads to a reduction in tool costs (e.g.: reduction in the number of tools per vehicle-model from five to three). This clause motivates suppliers to provide any expertise not possessed by the auto-maker at the earliest possible opportunity. The converse of this argument runs as follows: if the auto-maker were to pay for all the modifications originating with it, tool-makers would not be motivated to compensate for them and would thus become less involved in the planning stages.[2] This incentive system has already been observed at firm J by Aoki (1994), who maintains that the more auto-makers protect sub-contractors from risk, i.e. the more responsibility auto-makers assume for cost overruns resulting from modifications, the less incentive suppliers will have to pursue innovation on their own.
(2) When suppliers pay the costs for Phase 1 modifications, they are encouraged to propose only those improvements that will result in lower tool costs. This is because, when suppliers lower the cost for tools during Phase 1, they improve their own profit margin, since they are contractually guaranteed payment at the price fixed during initial negotiation. Improvements originating with suppliers "go straight into the suppliers' own pockets".
(3) Auto-makers have an incentive to identify needed modifications during Phase 1, since it is they who will pay during Phase 1. This is the only exception to the fixed-price nature of the contract.
(4) When assuming total responsibility for tool design under co-development systems, suppliers pay the costs for all modifications originating with them. The high cost of Phase 2 modifications acts as an incentive for identifying the need for modifications during Phase 1.
To sum up: since all Phase 2 modifications represent increased costs for the party identifying the need for them, this acts as an incentive for early identification. During Phase 1, suppliers are motivated to reduce the costs of the tools for which they are responsible by improving their design.

Measuring supplier performance

The request that instigated our research, which was made by Auto-Maker X, created problems when it came to working with the suppliers. These suppliers were competing with each other and were conducting negotiations with Auto-Maker X at the time of the research. The problems were solved due to both the credibility previously established by the field researcher (Garel, 1994), and to lengthy discussions undertaken with each supplier. A questionnaire and survey agreement enabled each supplier to understand our study objectives, and to prepare for each of our visits. Our investigation sought to evaluate the effects of co-development on the strategy, organization, and resources (human, design, plant, etc.) of these firms; and on the customer/supplier relationship from the viewpoint of the suppliers (commercial negotiation, contract signing, work at the planning stage, etc.). Two studies devoted to Phase 2 modifications for TR and CD projects and to the economic performances of these firms were also conducted.

3. Results of the co-development performance measurement

A reduction in tool costs

2 Suppliers can, however, contest the pertinence of a modification required by Auto-Maker X by referring it to a panel of peer assessors that meets at the conclusion of the project.

Co-development generated a 7% reduction in tool costs at the end of Phase 1, whereas the traditional sub-contracting system posted a cost overrun of 11%. A tool-by-tool study shows that the reduction for the CD project reflects improvement in tool design during Phase 1, i.e. during participation of suppliers at the planning stage. For example, Supplier A succeeded in improving the process for one lot of tools under the CD project by reducing the number of tools from 12 to 4, representing a cost reduction of 48%. By contrast, the TR project registered an increase in the complexity of the tooling process during Phase 1 due to problems with delivering pertinent expertise in a logical sequence during the planning stage; to the lack of an improvement-incentive clause; and to the absence of the suppliers' own experts. We concluded that, under co-development, the Auto-Maker achieves savings equal to the cost overruns on the TR project, and that suppliers will increase their profit margins if they can reduce tool costs.

An increase in the negotiated price

For the two partners, what effect does co-development have on the negotiated tool price? It is clear that under co-development the auto-maker pays more for tools during the initial negotiation, since the suppliers must anticipate modifications and profit margins during a single negotiation, with no hope of renegotiation. In fact, under the CD project, negotiated tool prices were an average of 23% higher than initial costing or cost estimates. Under the TR project, the differential was 16% (discrepancy = 7%). For suppliers, this differential measures the cost of risks to come. Auto-Maker X did not, however, "push" the negotiation too hard for this initial co-development experiment under the CD project.

A sharply reduced investment in modifications

The number of Phase 2 modifications was significantly reduced. They accounted for 49% of estimated tool cost under the TR project, compared with only 15% under the CD project (delta = 34%). In other words, investment in modifications under co-development were divided by almost 3.5, the result of a major reduction in modification volume. This observation is unique in the history of the automotive industry.

Table 3: Overall Co-Development Balance Sheet

Auto-Maker		**Suppliers**	
PROFITS	LOSSES	PROFITS	LOSSES
Phase 1 Performance: **11%** Reduction in modifications: **34%**	Non-renegotiation of contract: **7%**	Phase 1 Performance: **7%** Non-renegotiation of contract : **7%**	Reduction in modifications*: **0%**
Total : + 38%		**Total : + 14%**	

* We agree with the suppliers in considering that the reduction in modifications constituted a net loss in revenues, compensated by advantages obtained in production management (plant-flow equalization during Phase 2 was much easier, and production-times were shortened), and by the possibility of doing other business (income-generating business) during the time-period freed by modification reduction. Therefor, as a working figure, we have entered 0.

Co-development is here the opposite of a no-win game. However, the aggregate-result effect conceals a genuine disparity. Only a supplier-by-supplier profit/loss breakdown (still in terms of the TR/CD differential) can provide the clear demonstration making further analysis possible (Table 4).

Table 4: Co-development profit/loss matrix

		Auto-Maker X	Suppliers
Supplier A	Phase 1 Performance	PROFIT: 18%	PROFIT: 19%
	Non-renegotiation of contract	LOSS: 16%	PROFIT: 16%
	Modification reduction	PROFIT: 23%	-
	TOTAL	**PROFIT: 25%**	**PROFIT: 35%**
Supplier B	Phase 1 Performance	PROFIT: 10%	PROFIT: 0.1%
	Non-renegotiation of contract	PROFIT: 1%	LOSS : 1%
	Modification reduction	PROFIT: 25%	-
	TOTAL	**PROFIT: 36%**	**LOSS: 0.9%**
Supplier C	Phase 1 Performance	PROFIT: 0%	PROFIT: 4%
	Non-renegotiation of contract	LOSS: 6%	PROFIT: 6%
	Modification reduction	PROFIT: 68%	-
	TOTAL	**PROFIT: 62%**	**PROFIT: 10%**
Supplier D	Phase 1 Performance	PROFIT: 7%	LOSS: 12%
	Non-renegotiation of contract	LOSS: 21%	PROFIT: 21%
	Modification reduction	PROFIT: 17%	-
	TOTAL	**PROFIT: 3%**	**PROFIT : 9%**

There is a clear differential in these results: between profits and losses, between profit levels, between customer and suppliers, and among the various suppliers. How can these be explained?

4. Earning profits from the co-development situation

Co-development is advantageous to those suppliers capable of developing their design expertise over the long term.

Supplier expertise

Tool-maker profitability during Phase 1 is heavily dependent on engineering expertise. We have noted and verified a strong positive correlation between supplier performance and supplier design-capacity as measured in a given supplier's (1) human resources (Kay 1993; Grant 1991); (2) technological resources; and (3) organizational resources.

Table 5: Selected data on supplier engineering-resources[3]

Suppliers	Engineering staff (studies, programming and simulation)	Design staff as a % of firm's total work force	Total number of individuals qualified to participate in planning	Existence of a project structure	Digital Studies	Rate of study sub-contract-ing	Number of CAD / CAM work-stations
A	base 100	base 100	base 100	yes	yes	average	base 100
B	33%	84%	20%	yes	yes	low	50%
C	50%	123%	50%	yes	yes	average	75%
D	20%	130%	30%	no	no	high	25%

The Supplier B and D age-pyramids are relatively older than those of Suppliers A and C, a difference explained by the fact that design-department employees tend to be younger than those in other departments, and reflecting the considerable investment made by Suppliers A and C in a youthful and highly-qualified work force.[4] These young recruits also reflect high technological investment in digitalization and simulation—heavy investments[5] enabling these

3 N.B. for reasons of confidentiality, we decided to express the data relative to Suppliers B, C, and D in a percentage of the base 100 corresponding to Supplier A, and to mask data on sub-contracting rates for design studies (average rate = approximately 50%).

4 It is nevertheless the most highly-qualified suppliers, and often those of longest-standing, who participated in the auto-maker's Phase 1 planning stage. It should also be noted that metal-stamping as a field has historically had a long tradition of apprenticeship.

5 For example, apart from training costs, a fully-equipped 3-D CAD workstation costs approximately FF 300,000.

suppliers to reduce design time and improve the management of unforeseen Phase 1 modifications.

Tool-Maker D has not developed a design department or planning facilities and, in the absence of a project team, this firm—small in size and European in scope—cannot offer co-development expertise to its customers. Its design department has not been significantly modernized. Studies are not digital, and investments in CAD are low. Despite a large design staff in terms of percentage of total work force, Supplier D sub-contracts much of its design-study work. However, this sub-contracting is poorly handled and creates a dependency situation for the tool-maker in relation to its own design-study suppliers.[6] The lack of project structure has created coordination problems between customer and supplier. Supplier D is the only one which did not reap any advantages from participation in Phase 1, and modification reduction was negligible. In contrast to the operations carried out with Suppliers A, B, and C, the auto-maker's engineers were forced to make trips during Phase 2 to the premises of tool-maker D more often under the CD project than under the TR project, in order to compensate for this lack of skills (Table 6). Co-development revealed the structural weaknesses of this supplier.

Table 6: Number of monthly visits to suppliers by Auto-Maker X representative during Phase 2

Suppliers	Non Co-Development	Co-Development
A	1	1
B	4	1
C	2	0.5
D	0.5	2

Tool-Maker B developed its design resources extensively for the planning stage, and also implemented a dedicated project structure. The design-department work force increased by 150% over four years. This firm has concluded partnership contracts with outside design/planning consultants in order to strengthen its internal design resources. And, in order to help its partners adapt to the specifics of tool-making, the firm ultimately provided computer work-stations, software, and training programs for design-consultancy employees. Here, the dependency that holds Supplier D back has been addressed and remedied. (b) Over the past two years, Supplier B has gradually implemented a project structure cloned from that of Auto-Maker X. Internally, this project structure strengthens the relationship between the engineering and other departments. However, the performance of Tool-Maker B (overall loss of 0.9%) in the TR/CD comparison does not take into account the reorganization carried out following the CD project. The shift to co-development served as a strong incentive to this supplier to transform its structure and resources.

Tool-Maker A is positioned as a complete service-provider from the design of auto-body components to their final assembly. This supplier earned a substantial profit from co-development in the pre-production planning stage (profit of 35%). The firm developed its digital design and R&D departments extensively, and five years ago implemented a "heavyweight" project structure (Clark & Wheelwright 1992). Within the firm, organization according to project is a factor which promotes consistency. The project structure "holds together" all the investments and reorganizations by linking them to one another within a coherent system. It is also an attempt to duplicate the auto-maker's own organization, thus

6 The field covered by these design consultancies is industrial design in general and not machine-tools in particular. This non-specificity is reflected in the tardy identification of problems, since Supplier D does not possess the means for verifying all sub-contracted design work. Here we see that in order to sub-contract effectively, knowledge of how the job should be done must already be possessed internally. Tardy identification of errors creates tensions in the relationships between the design consultancy and the tool-maker's plant and are costly in terms of wasted time.

facilitating the customer/supplier interface. Supplier C, like Supplier A, has been developing its engineering skills for many years.
The ability to earn profits from participation in Phase 1 is thus strongly dependent on skills provided by the supplier. A skill-based approach puts the interpretation of performance in terms of incentives into perspective. Economic incentives are not in themselves sufficient to mobilize suppliers at the inception of a project. Although they positively affect both the early identification of required modifications and tool-cost reduction, profits are largely generated by tool-makers' skills, and not merely by these economic incentives. No economic incentive can turn a "numskull" into a "genius". Shifting economic responsibility onto the shoulders of the tool-maker is not enough; the means through which the tool-maker can assume this responsibility must also be provided by the organization. The way to do this is through participation in the planning stage, which gives credibility to the economic parameters. When the auto-maker invites its suppliers to participate in the project-planning stage, it gives them an opportunity to anticipate future project problems from the start. Economic incentives cannot be divorced from the organizational context in which they are operative. Economic incentives alone, therefore, are not enough to mobilize tool-makers at the design phase. Put another way, changes in organizational method will have little impact when not combined with changes in motivational method.

The long-term stability of the co-development relationship

Skills acquisition and investment by suppliers implies the extension of the inter-corporate relationship beyond a single project. Duration over time builds trust and develops learning. It also represents a guarantee of revenues, i.e. profit expectations are increased if the contract is renewed without subterfuge on either side. Suppliers will not undermine the interests of a customer that can guarantee steady revenues. Under the system of joint participation described by Imaï & Itami (1984), the two parties agree to renew their cooperative venture if each one has fulfilled its obligations. Game theory demonstrates that the duration of the relationship constitutes an incentive to cooperate. In a survey dealing with the American and Japanese car industries, Cusumano & Takeishi (1991) note that the relationship between contractors and auto-makers lasts for over ten years. For Donada & Kesseler (1997), the relationship between customer and supplier involved in co-development relationships today lasts for an average of 23 years. Co-development is conceived as a game that is continuously replayed, but its total lifespan is determined by results. Although co-development reflects a strategic change for Auto-Maker X, and although it involves a longer-lasting relationship than the traditional one for design sub-contracting, the customer still does not guarantee the supplier that it will be systematically selected for each new development. Behind this uncertainty, suppliers perceive a contradiction between, on one side, a coherent and motivating proposition from the Auto-Maker X management on partnerships with suppliers; and, on the other, organized debate within the firm on the desirability of an alternate method ("what if, ultimately, selection of the lowest bidder turned out to be the least costly solution?"). This vacillation worries suppliers. Co-development—and the commitment to long-term organization and investment it involves—requires a degree of stability in the organizational choices made by each of the partners. "Our investment strategies are strongly dependent on the continuation of a sustained volume of stable operations in the future" (all suppliers). In today's context of drastic reduction in design costs by auto-makers, the pressure on suppliers at the time of negotiation is very strong. The cost factor, as a determinant in the selection of suppliers, is indeed an integral part of the inter-corporate cooperation system. The estimated/negotiated cost differential observed between TR and CD projects (+7%) is sharply reduced for projects coming after the initial CD project. This pressure on prices reduces revenues, affects supplier profit margins adversely, and over time raises the question of how

long co-development can be sustained: “like other auto-makers, X requests a 20% reduction for each new project; the problem with a 20% reduction is how to maintain profit margins” (all suppliers).
Duration does not depend solely on the amount of time allowed by the customer for the co-development relationship. It is also a function of the co-development strategy of management and suppliers. What is the “strategic intention” (Hamel & Prahalad, 1989) of these managers in terms of co-development? “Strategy” is understood in this context as the fit an organization achieves between its own resources/skills and the opportunities/risks created by its external environment (Hofer & Schendel, 1978). The formulation of medium-term strategy is the only way to give coherence to the investment and organizational choices implemented by suppliers in the context of co-development. The tool-makers’ strategies are closely linked to the proportion of their revenues accounted for by Auto-Maker X. As it happens, Auto-Maker X is a major customer for the suppliers we studied. The only supplier-managers who failed to offer a strategic vision were those of Supplier D. They consider that the implementation of co-development is “unnatural” since firms are not intended to cooperate, but to organize their relationship via the market. This supplier’s lack of project structure and investment in design skills reflects its lack of strategic perspective. By contrast, the investment of tens of millions of French francs in an ultra-modern plant, the development of engineering skills, the implementation of data systems, and the modernization of organizational systems at Supplier C reflect a strong strategic vision.

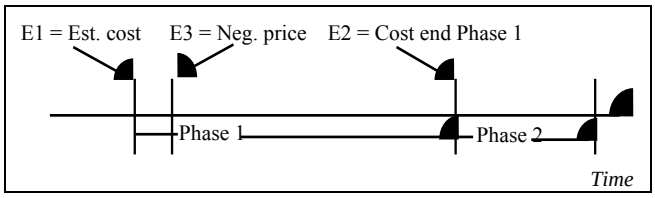
Conclusion

For an activity as strategically important as that described, co-development must be given comparative priority on the market. For the customer, co-development is the most efficient means to acquire a strategic resource which is not possessed by the firm itself. Under co-development, it is crucial for the customer to have suppliers who can identify, analyse, and solve problems. Not all suppliers have the right stuff to be effective co-development partners. The suppliers that reap advantages from co-development are those that make a sustained investment in the resources—primarily non-material ones—that build design skills. These skills enable such suppliers to exploit the opportunity offered by the decision of Auto-Maker X to out-locate. However, the type of out-location we have studied is contingent on political and historical factors that may create new circumstances in which Auto-Maker X will be impelled to re-integrate the operation involved. But the behavior of competing auto-makers is also reversible: their own organizational costs may lead them to out-locate the design and production of stamping tools. Auto-Maker X may even push them to do so by having become a “teaching customer” (Garel, & Kesseler, 1998) for suppliers.
Our study, closely focussed on machine tools for the automotive industry, leaves some consequences of co-development unexamined. For example, we have not studied the effects of this new organizational method on development time-frames, a major factor in the competition between firms developing new products. The development time-frame was shortened by over 10% between TR and CD projects, a tendency that accelerates with subsequent projects. Also unexamined are the effects of co-development on human-resource management (e.g.: stress and sometimes professional burn-out at the end of certain co-development projects; the effect on the relationship between project teams of coexisting but differing modes of customer relations practiced within the same firm). Nor have we further examined the effects of co-development on the machine-tool suppliers market. Today we are witnessing a definite trend towards vertical integration (e.g.: Comau in Italy) reflecting demands for industrial competence from design through production; and towards a widening gap between the top-ranking suppliers (co-developers) and those below them. Inter-corporate

cooperative efforts are redefining the frontiers of the firm itself (Garrouste, 1997), and are diversifying the nature of inter-organizational relationships.

APPENDIX

Below we present the calculation method, formulated *ad hoc* for our research purposes, used to arrive at the various differentials enabling us to measure co-development performance. With E1 = estimated cost, E2 = cost at end of Phase 1, E3 = negotiated price, E4 = cost of Phase 2 modifications.



suppliers	tool reference	cost	cost and price	results
A (resp B, C, D)	detail by tool in lot	E1..... and E1..... and E4.....	.....E2..... .....E3.....	diff. E1and E2 in % diff. E1 and E3 in % E4 in % of E1
	total lot	∑E1..... and ∑E1..... and ∑E4.....	.....∑E2..... .....∑E3.....	diff. ∑E1 and ∑E2 in % diff. ∑E1 and ∑E3 in % ∑E4 in % of E1
total suppliers		∑(∑E1)..... and ∑(∑E1)..... and ∑(∑E4).....	.....∑(∑E2)..... .....∑(∑E3).....	diff. ∑(∑E2) and ∑(∑E1) = performance in Phase 1 diff. ∑(∑E1) and ∑(∑E3) = effect of non-renegotiation of contract ∑(∑E4) in % of E1 = modification reduction

The above table was drawn up for both the CD and TR projects. The data on tables 3 and 4 in the body of the article show the differentials between the results obtained for each one of the projects (double-framed box in the above table).